CLAIMS

I/we claim:

[c1] A method for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

directing the radiation along a reticle radiation path segment toward a reticle;

passing the radiation from the reticle and to the microlithographic substrate along a substrate radiation path segment at the microlithographic substrate;

moving the reticle along a reticle path generally normal to the reticle radiation path segment; and

moving the microlithographic substrate relative to the radiation path along a substrate path, the substrate path having a first component generally parallel to the substrate radiation path segment, and the substrate path having a second component generally perpendicular to the substrate radiation path segment, wherein the microlithographic substrate moves generally parallel to and generally perpendicular to the substrate radiation path segment toward and away from the reticle while the reticle moves along the reticle path.

[c2] The method of claim 1 wherein the radiation includes a beam having a beam width at the microlithographic substrate, and wherein moving the microlithographic substrate includes oscillating the microlithographic substrate

toward and away from the reticle along an axis generally parallel to the substrate radiation path segment, further wherein a motion of the microlithographic substrate is periodic and wherein moving the microlithographic substrate includes moving the microlithographic substrate for one period during the time the microlithographic substrate moves transverse to the beam by a distance of one beam width or about one beam width.

[c3] The method of claim 1 wherein the radiation includes a beam having a beam width at least proximate to an intersection between the beam and the microlithographic substrate, and wherein moving the microlithographic substrate includes oscillating the microlithographic substrate toward and away from the reticle along an axis generally parallel to the substrate radiation path segment, further wherein a motion of the microlithographic substrate is periodic and wherein moving the microlithographic substrate includes moving the microlithographic substrate for an integer number of periods during the time the microlithographic substrate moves transverse to the beam by a distance of one beam width or about one beam width.

[c4] The method of claim 1 wherein moving the reticle includes moving the reticle along a reticle path generally normal to the reticle radiation path segment at least proximate to a point where the radiation impinges on the reticle.

[c5] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a substrate path having a first component generally parallel to the substrate radiation path segment of the radiation at least proximate to a point where the radiation strikes the microlithographic substrate, the substrate path having a second component generally perpendicular to the substrate radiation path segment at least proximate to a point where the radiation strikes the microlithographic substrate.

[c6] The method of claim 1, further comprising selecting the radiation-sensitive material to include a coating of photoresist material.

[c7] The method of claim 1, further comprising selecting the radiation to have a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c8] The method of claim 1, further comprising orienting a plane of the reticle approximately normal to the first direction.

[c9] The method of claim 1 wherein moving the microlithographic substrate includes simultaneously moving the microlithographic substrate parallel to and perpendicular to the second direction.

[c10] The method of claim 1 wherein moving the microlithographic substrate includes oscillating the microlithographic substrate toward and away from the reticle along a first axis generally parallel to the substrate radiation path segment while the microlithographic substrate simultaneously moves along a second axis generally perpendicular to the substrate radiation path segment.

[c11] The method of claim 1 wherein moving the reticle includes moving the reticle in a direction opposite to the second component of motion of the microlithographic substrate.

[c12] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a curved path.

[c13] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a straight path having a first segment directed toward the reticle and a second segment directed away from the reticle.

[c14] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a path describing a square wave.

[c15] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a path describing a sinusoidal wave.

[c16] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a path that describes a periodic, triangular profile.

[c17] The method of claim 1 wherein the microlithographic substrate has first and second fields, and wherein the method further comprises:

aligning the radiation path with the first field;

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the first field;

repositioning at least one of the microlithographic substrate and the radiation path relative to the other to align the radiation path with the second field; and

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the second field.

[c18] The method of claim 1, further comprising selecting the reticle radiation path segment to be approximately parallel to the substrate radiation path segment.

[c19] The method of claim 1 wherein moving the microlithographic substrate includes moving the microlithographic substrate relative to a focal plane of the radiation passing through the reticle.

[c20] The method of claim 1 where a reduction lens is positioned between the reticle and the microlithographic substrate and wherein the method further comprises moving the reduction lens axially relative to the microlithographic substrate to move a focal plane of the radiation axially relative to the microlithographic substrate.

[c21] A method for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

directing a beam of the radiation along a radiation path in a first direction toward a reticle;

passing the radiation through an aperture of the reticle and to the microlithographic substrate along the radiation path in a second direction, the beam having a beam width at least proximate to an intersection between the beam and the microlithographic substrate;

focusing the radiation toward a focal plane;

moving the reticle relative to the radiation path along a reticle path generally normal to the first direction; and

moving the microlithographic substrate relative to the radiation path and the focal plane along a substrate path, the substrate path having a first component generally parallel to the second direction, the substrate path having a second component generally perpendicular to the second direction, the microlithographic substrate simultaneously moving parallel to and perpendicular to the second

direction while the reticle moves along the reticle path, and wherein the microlithographic substrate oscillates in a periodic manner toward and away from the reticle along an axis generally parallel to the second direction, further wherein moving the microlithographic substrate includes moving the microlithographic substrate for an integer number of periods during the time the microlithographic substrate moves transverse to the beam by a distance of approximately one beam width.

[c22] The method of claim 21 wherein moving the reticle includes moving the reticle along a reticle path generally normal to the first direction of the radiation path at least proximate to a point where the radiation impinges on the reticle.

[c23] The method of claim 21 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a substrate path having a first component generally parallel to the second direction of the radiation at least proximate to a point where the radiation strikes the microlithographic substrate, the substrate path having a second component generally perpendicular to the second direction of the radiation at least proximate to a point where the radiation strikes the microlithographic substrate.

[c24] The method of claim 21, further comprising selecting the radiation-sensitive material to include a coating of photoresist material.

[c25] The method of claim 21, further comprising selecting the radiation to have a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c26] The method of claim 21, further comprising orienting a plane of the reticle approximately normal to the first direction.

[c27] The method of claim 21 wherein moving the reticle includes moving the reticle in a direction opposite to the second component of motion of the microlithographic substrate.

[c28] The method of claim 21 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a curved path.

[c29] The method of claim 21 wherein moving the microlithographic substrate includes moving the microlithographic substrate along a path describing a sinusoidal wave.

[c30] The method of claim 21 wherein the microlithographic substrate has first and second fields, and wherein the method further comprises:

aligning the radiation path with the first field;

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the first field;

repositioning at least one of the microlithographic substrate and the radiation path relative to the other to align the radiation path with the second field; and

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the second field.

[c31] The method of claim 21, further comprising selecting the first direction to be approximately parallel to the second direction.

[c32] A method for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

directing the radiation along a radiation path in a first direction toward a reticle;

orienting a plane of the reticle at a first non-normal angle relative to the first direction;

passing the incident radiation through an aperture in the reticle and to the microlithographic substrate along the radiation path in a second direction;

positioning a plane of the microlithographic substrate at least approximately normal to the second direction;

moving the microlithographic substrate relative to the radiation along a substrate path at least approximately normal to the second direction; and

moving the reticle relative to the radiation along a reticle path, the reticle path being inclined relative to the substrate path by a second non-normal angle approximately equal to the first non-normal angle.

[c33] The method of claim 32, further comprising selecting the first and second non-normal angles to have a value of about 400 microradians less than a normal angle.

[c34] The method of claim 32, further comprising selecting the radiation-sensitive material to include a coating of photoresist material.

[c35] The method of claim 32 wherein moving the reticle includes moving the reticle in a direction generally opposite the motion of the microlithographic substrate.

[c36] The method of claim 32 wherein the microlithographic substrate has first and second fields, and wherein the method further comprises:

aligning the radiation path with the first field;

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the first field;

repositioning at least one of the microlithographic substrate and the radiation path relative to the other to align the radiation path with the second field; and

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the second field.

[c37] The method of claim 32, further comprising selecting the first direction to be at least approximately parallel to the second direction.

[c38] The method of claim 32, further comprising:

passing the radiation through at least one reducing lens having a reduction factor;

moving the microlithographic substrate at a first rate; and

moving the reticle at a second rate that is less than the first rate by approximately the reduction factor.

[c39] A method for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

directing the radiation along a radiation path in a first direction toward a reticle;

orienting a plane of the reticle approximately normal to the first direction;

passing the radiation through the reticle and to the microlithographic substrate along the radiation path in a second direction;

orienting the microlithographic substrate at first angle inclined relative to the second direction;

moving the microlithographic substrate relative to the radiation along a substrate path oriented at least approximately parallel to the first angle; and

moving the reticle relative to the radiation along a reticle path oriented at a second angle inclined relative to the second direction.

[c40] The method of claim 39 wherein the radiation passes through a lens having a reduction factor, and wherein the second angle is approximately equal to the first angle divided by the reduction factor.

[c41] The method of claim 39, further comprising selecting the first angle to have a value of about 100 microradians less than a normal angle and selecting the second angle to have a value of about 400 microradians less than a normal angle.

[c42] The method of claim 39, further comprising selecting the radiation-sensitive material to include a coating of photoresist material.

[c43] The method of claim 39 wherein moving the reticle includes moving the reticle in a direction generally opposite to the motion of the microlithographic substrate.

[c44] The method of claim 39 wherein the microlithographic substrate has first and second fields, and wherein the method further comprises:

aligning the radiation path with the first field;

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the first field;

repositioning at least one of the microlithographic substrate and the radiation path relative to the other to align the radiation path with the second field; and

moving the reticle and the microlithographic substrate relative to each other while the radiation path is aligned with the second field.

[c45] The method of claim 39, further comprising selecting the first direction to be approximately parallel to the second direction.

[c46] An apparatus for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

a radiation source positioned to direct a selected radiation along a radiation path;

a reticle positioned in the radiation path, the reticle being configured to selectively direct at least a portion of the radiation toward a microlithographic substrate, the reticle being coupled to at least one actuator to move relative to the radiation path in a direction generally perpendicular to the radiation path; and

a substrate support having a support surface positioned to support a microlithographic substrate in the radiation path with the microlithographic substrate receiving radiation from the reticle, wherein the substrate support is coupled to at least one actuator to move relative to the radiation path along a substrate support path, the substrate support path having a first component generally parallel to the radiation path proximate to the substrate support, the substrate support path having a second component generally perpendicular to the radiation path proximate to the substrate support, the substrate support being movable along both the first and second components of the substrate support path while the reticle moves along the reticle path.

[c47] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move simultaneously along both the first and second components of the substrate support path while the reticle moves along the reticle path.

[c48] The apparatus of claim 46 wherein the radiation includes a radiation beam having a beam width proximate to the substrate support surface and wherein the substrate support is coupled to at least one actuator to oscillate in a periodic manner toward and away from the reticle along an axis generally parallel to the second direction, further wherein the substrate support is configured to move for one period during the time the substrate support moves transverse to the beam by a distance of approximately one beam width.

[c49] The apparatus of claim 46 wherein the radiation includes a radiation beam having a beam width proximate to the substrate support surface and wherein the substrate support is configured to oscillate in a periodic manner toward and away from the reticle along an axis generally parallel to the second direction, further

wherein the substrate support is configured to move for an integer number of periods during the time the substrate support moves transverse to the beam by a distance of approximately one beam width.

[c50] The apparatus of claim 46 wherein the radiation source is configured to emit radiation having a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c51] The apparatus of claim 46 wherein a plane of the reticle is oriented approximately normal to the first direction.

[c52] The apparatus of claim 46 wherein the substrate support is configured to move simultaneously parallel to and perpendicular to the second direction.

[c53] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to oscillate toward and away from the reticle along a first axis generally parallel to the second direction while moving along a second axis generally perpendicular to the second direction.

[c54] The apparatus of claim 46 wherein the reticle is coupled to at least one actuator to move in a direction opposite to the second component of motion of the substrate support.

[c55] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move along a curved path.

[c56] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move along a straight path having a first segment directed toward the reticle and a second segment directed away from the reticle.

[c57] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move along a path describing a square wave.

[c58] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move along a path describing a sinusoidal wave.

[c59] The apparatus of claim 46 wherein the substrate support is coupled to at least one actuator to move along a path describing a periodic, triangular profile.

[c60] The apparatus of claim 46 wherein the microlithographic substrate has first and second fields, and wherein the reticle is coupled to at least one actuator to sequentially scan across the first and second fields.

[c61] The apparatus of claim 46 wherein the reticle includes a reticle aperture sized to pass a portion of the radiation toward the microlithographic substrate to form an image on the microlithographic substrate.

[c62] An apparatus for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

a source of radiation positioned to direct a beam of selected radiation along a radiation path;

a substrate support having a support surface positioned to support a microlithographic substrate in the radiation path, wherein the substrate support is coupled to at least one actuator to move relative to the radiation path along a substrate support path, the substrate support path having a first component generally parallel to the radiation path proximate to the substrate support, the substrate support path having a second component generally perpendicular to the radiation path proximate to the substrate support, the substrate

support being movable along both the first and second components of the substrate support path to describe a periodic motion, the beam having a beam width proximate to the substrate support surface;

a reticle positioned in the radiation path between the source of radiation and the substrate support to intersect the beam and direct at least a portion of the beam along the radiation path to the substrate support, the reticle being coupled to at least one actuator to move relative to the radiation path in a direction generally perpendicular to the radiation path and opposite the first component of the substrate support path; and

a controller operatively coupled to the reticle and the substrate support to move the substrate support for an integer number of periods during the time required for the microlithographic substrate to move transverse to the beam by at least one beam width.

[c63] The apparatus of claim 62 wherein the radiation source is configured to emit radiation having a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c64] The apparatus of claim 62 wherein the substrate support is coupled to at least one actuator to move along a curved path.

[c65] The apparatus of claim 62 wherein the substrate support is coupled to at least one actuator to move along a straight path having a first segment directed toward the reticle and a second segment directed away from the reticle.

[c66] The apparatus of claim 62 wherein the substrate support is coupled to at least one actuator to move along a path describing a square wave.

[c67] The apparatus of claim 62 wherein the substrate support is coupled to at least one actuator to move along a path describing a sinusoidal wave.

[c68] The apparatus of claim 62 wherein the substrate support is coupled to at least one actuator to move along a path describing a periodic, triangular profile.

[c69] The apparatus of claim 62 wherein the reticle includes a reticle aperture sized to pass at least a portion of the radiation beam toward the substrate support to form an image on the microlithographic substrate.

[c70] An apparatus for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

a source of radiation positioned to direct a beam of selected radiation along a radiation path;

a substrate support configured to support a microlithographic substrate in the radiation path, wherein the substrate support is coupled to at least one actuator to move relative to the radiation path along a substrate support path, the substrate support path having a first component generally parallel to the radiation path proximate to the substrate support, the substrate support path having a second component generally perpendicular to the radiation path proximate to the substrate support, the substrate support being simultaneously movable along both the first and second components of the substrate support path to describe a periodic motion, the beam having a beam width proximate to the substrate support; and

a reticle positioned in the radiation path between the source of radiation and the substrate support to intersect the radiation beam, the reticle including at least one aperture and being positioned to pass the

radiation along the radiation path to the substrate support, the reticle being coupled to at least one actuator to move relative to the radiation path in a direction generally perpendicular to the radiation path and opposite the first component of the substrate support path; and

a controller operatively coupled to the reticle and the substrate support to move the substrate support for an integer number of periods during the time required for the entire width of the beam to pass over a point on the microlithographic substrate.

[c71] The apparatus of claim 70 wherein the radiation source is configured to emit radiation having a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c72] The apparatus of claim 70 wherein the substrate support is coupled to at least one actuator to move along a curved path.

[c73] The apparatus of claim 70 wherein the substrate support is coupled to at least one actuator to move along a straight path having a first segment directed toward the reticle and a second segment directed away from the reticle.

[c74] The apparatus of claim 70 wherein the substrate support is coupled to at least one actuator to move along a path describing a square wave.

[c75] The apparatus of claim 70 wherein the substrate support is coupled to at least one actuator to move along a path describing a sinusoidal wave.

[c76] The apparatus of claim 70 wherein the substrate support is coupled to at least one actuator to move along a path describing a periodic, triangular profile.

[c77] An apparatus for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

a source of radiation positioned to direct a selected radiation along a radiation path;

a substrate support having a support surface positioned to support a microlithographic substrate in the radiation path with a surface of the microlithographic substrate at least approximately normal to the radiation path, wherein the substrate support is coupled to at least one actuator to move relative to the radiation path along a substrate support path approximately normal to the radiation path; and

a reticle positioned in the radiation path between the source of radiation and the substrate support, the reticle being oriented at a first non-normal angle relative to the radiation path, the reticle being configured to pass at least a portion of the radiation along the radiation path to the substrate support, the reticle being coupled to at least one actuator to move relative to the radiation path along a reticle path, the reticle path being inclined relative to the substrate path by a second non-normal angle approximately equal to the first non-normal angle.

[c78] The apparatus of claim 77 wherein the first and second non-normal angles to have a value of about 400 microradians less than a normal angle.

[c79] The apparatus of claim 77 wherein the radiation source is configured to emit radiation having a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c80] The apparatus of claim 77 wherein the microlithographic substrate has first and second fields, and wherein the reticle is configured to sequentially scan across the first and second fields.

[c81] An apparatus for exposing a radiation-sensitive material of a microlithographic substrate to a selected radiation, comprising:

a source of radiation positioned to direct a selected radiation along a radiation path;

a substrate support configured to support a microlithographic substrate in the radiation path with a surface of the microlithographic substrate at a first non-normal angle relative to the radiation path, wherein the substrate support is coupled to at least one actuator to move relative to the radiation path along a substrate support path at least approximately parallel to the first non-normal angle; and

a reticle positioned in the radiation path between the source of radiation and the substrate support, the reticle being oriented at an at least approximately normal angle relative to the radiation path, the reticle being configured to pass at least a portion of the radiation along the radiation path to the substrate support, the reticle being coupled to at least one actuator to move relative to the radiation path along a reticle path oriented at a second non-normal angle relative to the radiation path.

[c82] The apparatus of claim 81 wherein the first non-normal angle has a value of about 100 microradians less than a normal angle and the second non-normal angle has a value of about 400 microradians less than a normal angle.

[c83] The apparatus of claim 81 wherein the radiation source is configured to emit radiation having a wavelength of from about 13 nanometers or less to about 365 nanometers.

[c84] The apparatus of claim 81 wherein the microlithographic substrate has first and second fields, and wherein the reticle is configured to sequentially scan across the first and second fields.